AGE AND GROWTH OF PIPER, *TRIGLA LYRA*, IN SARONIKOS GULF (GREECE)

by

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ABSTRACT. – Otoliths from 279 pipers, *Trigla lyra*, from Saronikos Gulf were used for age determinations. The occurrence of annuli on the otolith (sagitta) was confirmed, from which age and growth could be calculated ; annuli form during the winter period. The growth rate was estimated by back-calculation using the body length (Y) to otolith radius (X) relationship $Y = 1.3607 \cdot X^{1.356}$. Maximum age of fish collected was VII and maximum fork length estimated by von Bertalanffy equation was 740.49 mm. The length-weight relationship varies throughout the year, with a maximum in June. The male/female ratio is usually greater than one.

RÉSUMÉ. – Les otolithes (sagitta) de 279 grondins lyres, *Trigla lyra*, du Golfe de Saronikos, ont été utilisés pour la détermination de l'âge. La distribution de fréquence, exprimée en pourcentage du nombre de poissons, de la distance du nucleus aux anneaux et au bord suggèrent la validité de la position de l'anneau comme critère de l'évaluation de l'âge du grondin lyre. Les anneaux se forment pendant l'hiver. Le taux de croissance a été évalué en calculant la longueur du corps (Y) en fonction du rayon de l'otolithe (X) avec l'équation : $Y = 1.3607 \cdot X^{1.356}$. L'âge maximum des poissons examinés était de sept ans et la longueur maximum à la fourche estimée par l'équation de von Bertalanffy était de 740,49 mm. La relation longueur-poids varie durant l'année entière. Le poids maximum est atteint en Juin. Le sex-ratio mâles/femelles est en général plus grand que un.

The piper (*Trigla lyra* L., 1758) is a demersal fish that lives in muddy bottoms up to a maximum depth of 400 m. It is found in the Mediterranean and in the Eastern Atlantic, from the western coasts of Great Britain to the Gulf of Guinea. Mouneimne (1970) studied its age, growth, food and distribution in the area off Banyuls-sur-Mer (Mediterranean coasts of France), but otherwise there is little information regarding the life history of the species.

The piper is the only triglid in the Aegean Sea, where it is of some economic interest (Table I). The age and growth of the piper in the Saronikos gulf (Fig. 1) were studied in this paper.

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TABLE I. – Total catches in Kg of pipers from the Greek seas.

Year	Kgs	Year	Kgs
1971	26650	1975	48737
1972	29250	1976	28943
1973	44981	1977	25375

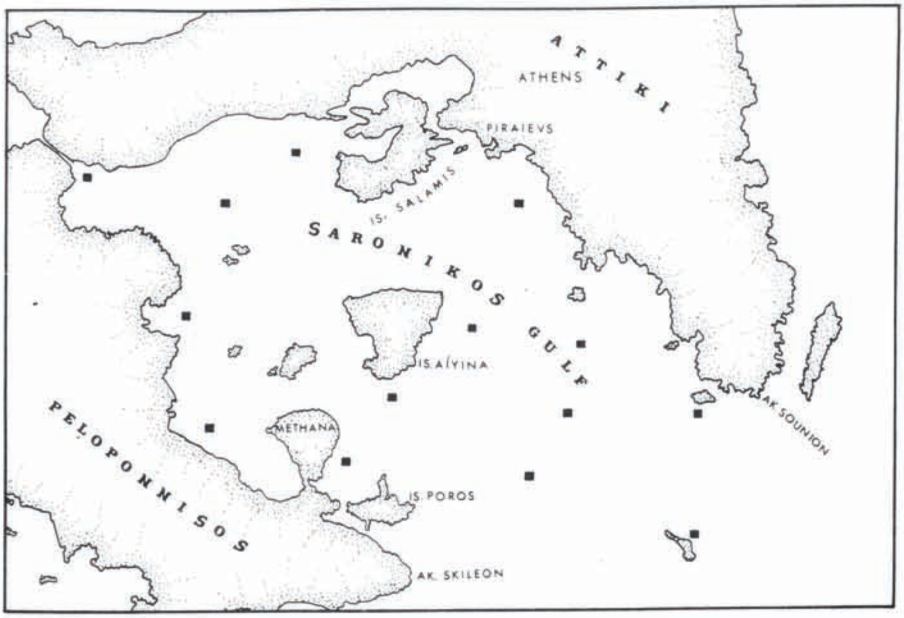

Fig. 1. – Saronikos Gulf. Large squares represent sampling stations.

MATERIAL AND METHODS

The study is based on 953 specimens caught in Saronikos gulf from June 1976 to April 1978. The samples include specimens from each season of the year and were caught by a commercial bottom trawler of 400 H.P. using a net with a cod-end mesh size of 14 mm between knots. The duration of each trawl haul varied between 20-30 min and rarely exceeded 45 min. The fork length (to nearest mm), weight (to 0.1 g) and gonad weight (to 0.01 g) were recorded. The sex was verified macroscopically for adults and microscopically for juveniles.

Age was determined by the otoliths (sagitta) because the scales were very small and the annuli were invisible. They were cleaned and preserved in glycerine until the time of study. Different methods for reading the otoliths were used. At the beginning the otoliths were examined in different liquids of high refractive index to improve visibility of the growth zones e.g. creosot, xylene, glycerine and ethyl alcohol. However, satisfactory results were not obtained. The best results were obtained after burning the otoliths at about 450°C for 2 min. The burning enhances the visibility of the annuli because the hyaline zones become brown while the opaque zones remain white. The burning technique was used in the growth studies of some triglid species by some authors, Mc Eachran and Davis, 1971 (*Prionotus evolans*), Elder, 1976 (*Chelidonichthys kumu*). The otoliths were then placed in a painted black petri dish of glycerine, with the concave surface up, and illuminated with reflected light, and read under a binocular microscope WILD M 8 at a magnification of 18 X.

The distance between the annuli was measured on the radius that connects the nucleus with the otolith rostrum. The shape of the rostrum varied from specimen to specimen, especially between juveniles, but this radius was prefered for the following reasons :

- The coefficient of variation for the calculated lengths at the end of each year of the first 4 years of life, varied from 4.84 to 10.13 (I = 7.43, II = 10.13, III = 5.42, IV = 4.84).
- The annuli on the rostrum show more contrast and therefore can be measured with more accuracy.
- Only ten per cent of the total number of the otoliths were unreadable.

The choice of suitable equations to verify the body length-otolith radius relationship, the back calculation of body length and determination of the parameters of the von Bertalanffy equation were made by a CONTROL DATA, 3300 computer.

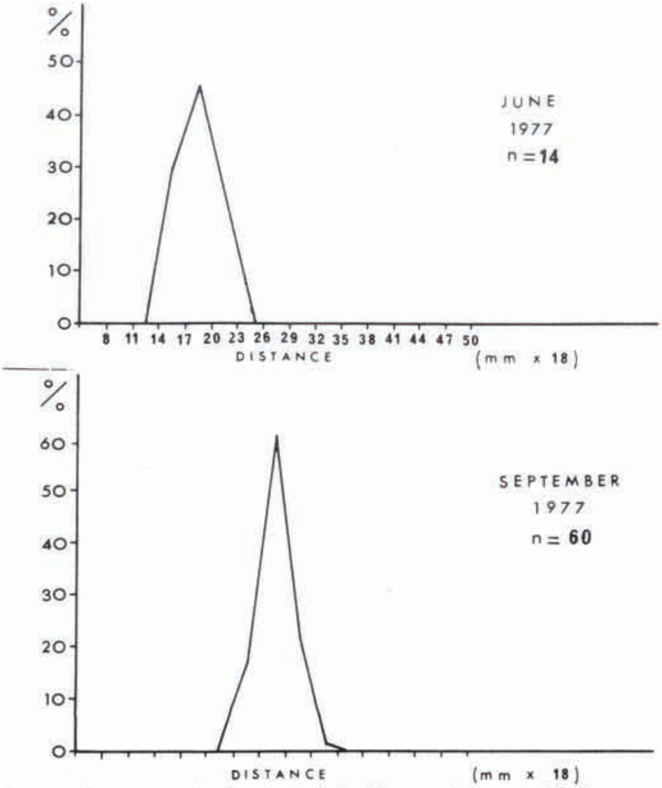

Fig. 2. – Percent frequency distribution of the distance in mm x 18 from nucleus to otolith margin et otoliths from pipers collected of Saronikos Gulf in 1977 and assigned to the 1977 year class.

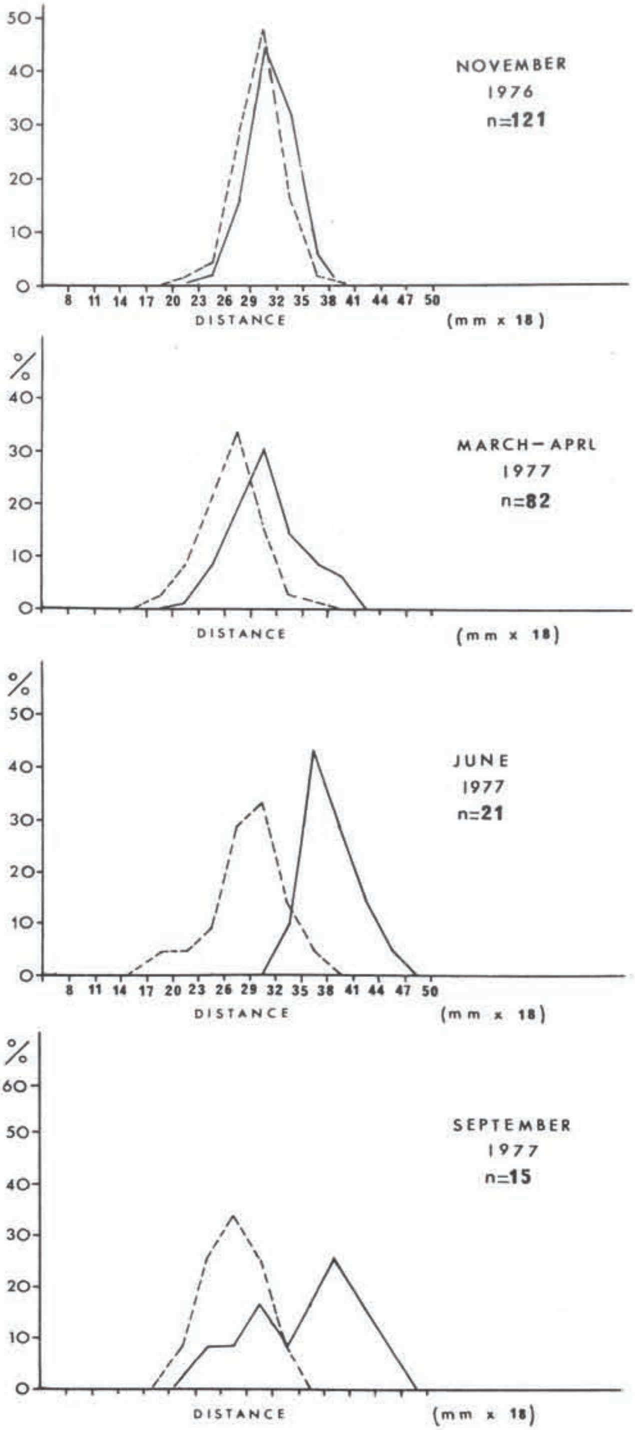

Fig. 3. – Percent fréquency distribution of the distance in mm x 18 from nucleus to annulus (broken lines) and to otolith margin (solid lines) of otoliths from pipers collected from Saronikos Gulf in 1976-1977 and assigned to the 1976 year class.

RESULTS AND DISCUSSION

Period of annulus formation and validation of ageing technique.

The time of annulus formation was determined by using pipers of age group 0-II. The otoliths from males and females were combined because no significant difference (t-test, $P > 0.05$) was found between the two sexes through the year with respect to the distance of the otolith nucleus from the first annulus or from the otolith margin.

The time of annulus formation was found from the seasonal changes of the distance between the last annulus and the otolith margin. The distribution of the above distance, as a percentage of the sample size is shown every three months from November 1976 to September 1977 for fish ageing 0 through II years old in the figures 2, 3 and 4.

The first annulus of the 1976 year class (Fig. 3) appeared in some fish in November 1976, before the completion of the first year of life. This early formation of the first annulus has also been observed in other species of the family e.g. *Prionotus evolans* (Mc Eachran and Davis, 1971). Only 121 specimens out of 182 caught in November 1976 completed the first annulus. Annulus formation is completed during the winter months but our lack of samples in that period of the year did not allow determination of the exact date of its completion. All the 1976 year class (82 specimens) caught at the end of March 1977 were assigned to age group I. Every month the otolith continuously enlarged beyond the first annulus until to the formation of the second one which begins to occur at the end of the autumn. In November 1976 the second annulus of the 1975 year class began to form (Fig. 4).

The changes of the distance between the annuli and the otolith margin in the older age groups was almost impossible to measure, because this distance became shorter and shorter with age.

It is very difficult to define the piper's age group using the Petersen's method. In the younger age groups this is probably due to the double spawning season ; while it is frequently not useful for the older age group.

Length frequency analysis.

The length frequency distribution (Fig. 5) of pipers in Saronikos gulf is based on the fork length at the time of capture of a sample of 798 individuals, caught from June 1976 to March 1977. The two sexes were combined because the difference in length between males and females of the same age group was not significant (t-test, $P > 0,05$).

Young-of-the-year appear as recruits in June ($\overline{FL}$ = 77,8 mm), increase in length quickly during the next months (September $\overline{FL}$ = 123.8 mm, November FL = 138.4 mm, March $\overline{FL}$ = 128,3 mm) and comprise the majority of the catch (June 19.3 %, September 73,6 %, November 90.4 % and March 88.1 %). The apparent jump in size from June to March reflects the mean growth in length the first year of life.

A large variation in length was observed in the sample caught in March 1977.

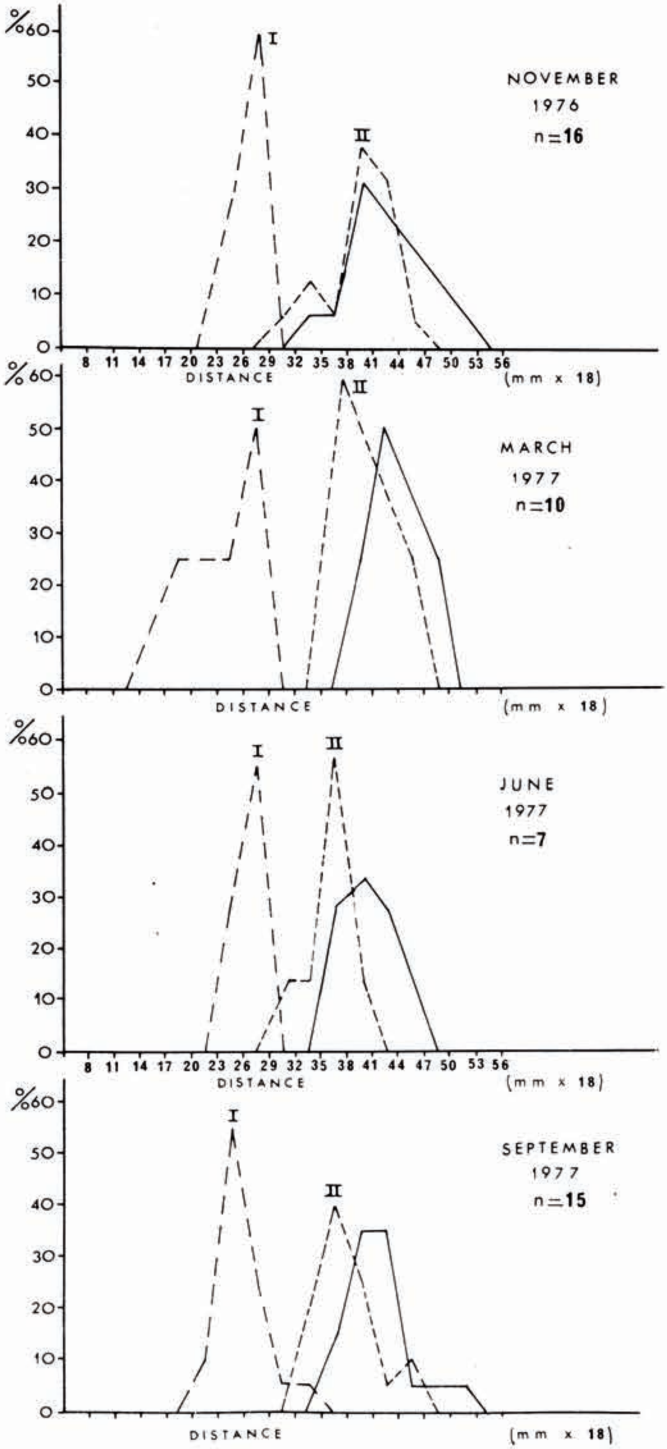

Fig. 4. – Percent frequency distribution of the distance in mm x 18 from nucleus to annulus (broken lines) and to otolith margin (solid lines) of otoliths from pipers collected from Saronikos Gulf in 1976-1977 and assigned to the 1975 year class.

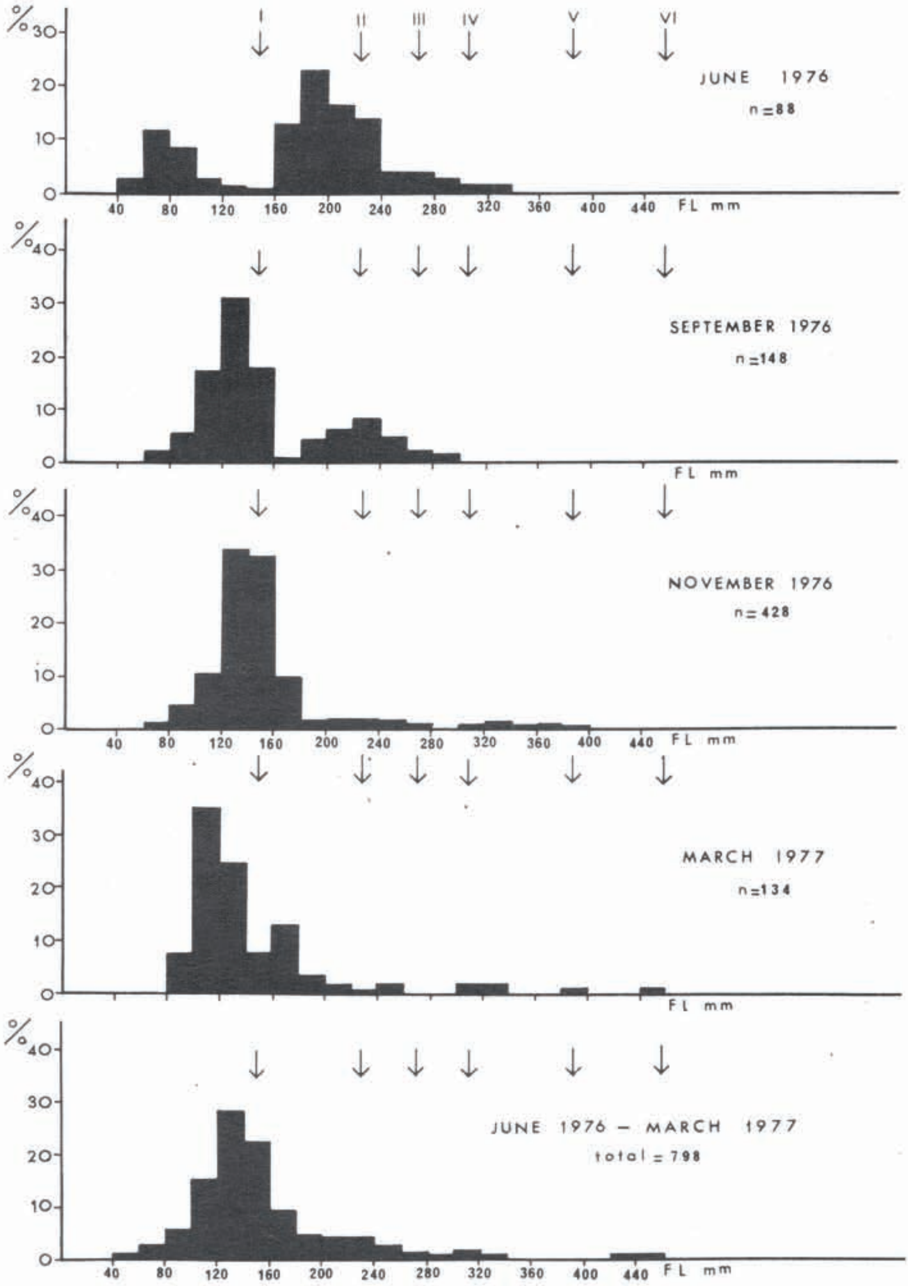

Fig. 5. – Length-frequency distribution of pipers caught every three months, from Saronikos Gulf between June 1976 and March 1977.

Despite having completed the first annulus the average length in this season was smaller than that in November 1976. This cannot be a sampling artifact because the number of samples at all of the lower and upper limits of age are quite large. The explanation I suggest is that pipers that were in the 60-170 mm range in November (1976) develop an annulus in the winter and by March (1977) a fraction of the larger of these migrate to another area. A similar phenomenon has been reported by Westrheim (1955) to explain the decrease in length, from October to December, of the *Parophrys vetulus* population in the Yaquina bay (coast of Oregon, USA).Then in early winter begun a second recruitment, and the juveniles are caught in March sample. If there was no migration, but only a second spawning, the March sample (Fig. 5) would be extremely bimodal ; but the size distribution shows only a higher peak between 100-140 mm corresponding to the average size of the pipers recruited in early winter and another smaller peak between 180-200 mm corresponding to the average size of the pipers which have not migrated yet. Further studies should clarify this point.

Composition by length and age.

The length frequency distribution (table 2) shows a considerable overlap between age groups 0 and I (100 mm). This can only be attributed to separated spawning period which becomes evident by the different times of recruitment (early summer and early winter). Fish of age groups 0 and 1 represent 81.3% of the total catch. Age groups I-IV present a limited overlap (40 mm) as expected in the case of groups I and II which overlap by 60 mm. The samples of age groups V-VII was limited and did not present any overlap.

The abrupt reduction in the number of fish which have completed the first annulus must be the result of fish migration away from the nursery grounds rather than a high natural and fishing mortality. Harden-Jones (1968) reports that the feeding grounds of adult fish are not the same as their spawning or nursery grounds. The migration may begin with the completion of the first annulus, in early spring, between the greater individuals. Thus, the high percentage of the March catch of I+ year old decreases in June and disappears progressively from September to November. Mouneimne (1970) refers to a similar migration of the piper in the Catalane Sea.

Growth in length.

The age determination of the piper is based on the measurements of the annuli that are formed on the otolith. The otolith was described by several authors (Chaine, 1956 ; Schmidt, 1968). Mouneimne (1970) calculated the age from the scales. The otolith radius in the same age group did not show any significant difference (t-test, $P > 0.05$) either between left and right otolith or males and females.

The body length-otolith relationship of Saronikos gulf pipers was estimated from a sample of 238 specimens (87 females, 141 males) caught in November 1976 and another of 51 (22 females, 29 males). All the specimens of the last sample had an age greater than two years and were caught between June 1976 and April 1978. Males and females were combined because no significant difference was observed between their back-calculated length in the same age group (t-test, $P > 0,05$).

TABLE II. – **Fork length distribution of the age groups of piper from Saronikos Gulf, November 1976 to September 1977.**

Length Interval (mm)	age group								Total
	0	I	II	III	IV	V	VI	VII	
40-60	3								3
60-80	6								6
80-100	8	8							16
100-120	22	43							65
120-140	53	56							109
140-160	40	74							114
160-180	6	42	2						50
180-200		12	11						23
200-220		5	20						25
220-240			17	4					21
240-260			3	6					9
260-280				3	2				5
280-300				1	1				2
300-320					8				8
320-340					2				2
340-360						1			1
360-380						2			2
380-400							2		2
400-420									-
420-440								1	1
440-460								1	1
n° of fish	138	240	53	14	13	3	2	2	465
average length	129,9	143,5	255,8	265,8	308,8	368	391	444	
increm^{nt} average (mm)	129,9	13,6	82,3	40,0	43,0	59,2	23,0	53.0	

Four equations (table 3) were examined to choose the best fit to the body length-otolith radius data. The criterion of the smallest variance (residual mean square), with the requirement that the equation has a biological meaning was used to choose a relationship. Of all the equations listed in Table 3 the power curve was chosen. The third degree polynomial shows the smallest variance but it cannot be interpreted biologically because :

- Y for X = 0-20 does not have any biological meaning.
- The maximum length (Y = 445 mm for X = 80) is much smaller than the one calculated by the von Bertalanffy equation (Ymax. = 740.49 mm).

TABLE III. – Function examined for the best fit of body length-otolith radius data.

Equation	Variance
$Y = A + B.x$	17.2769
$Y = A + B.x + C.x^2$	17.102
$Y = A + B.x + C.x^2 + D.x^3$	16.7507
$Y = A.x^B$	17.0758

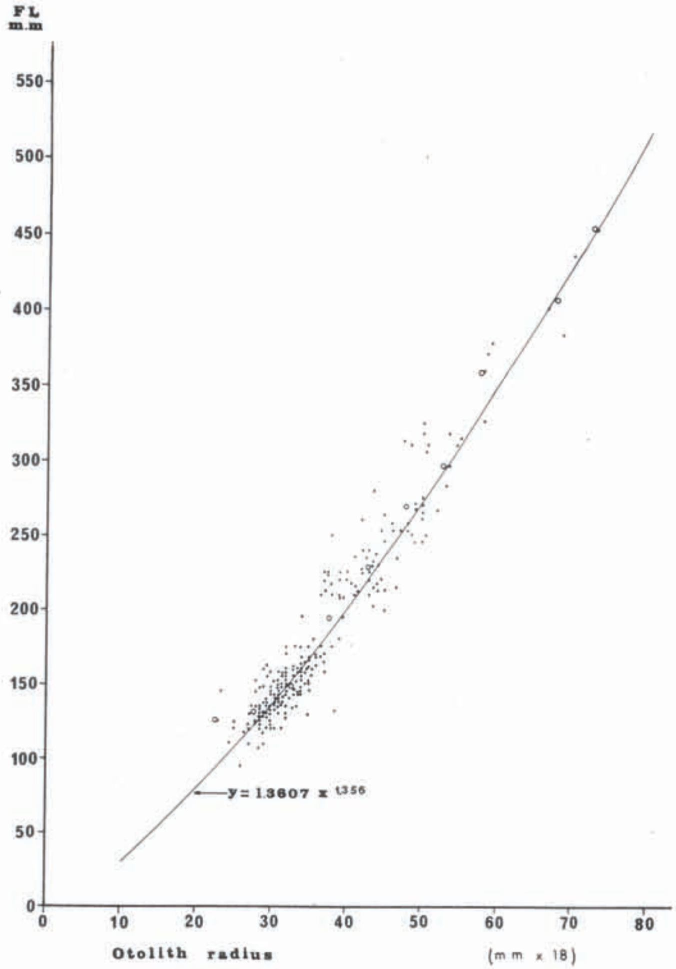

Fig. 6. – Relationship between fork length (mm) and otolith radius (mm x 18) for piper from Saronikos Gulf. The dots represent the plotting of each separate value and the small circles the average fork length of a group of specimens for every five units (mm x 18) of otolith radius.

Thus the back calculated lengths were estimated by the power equation (Fig. 6) :

$$Y = 1.3605 \cdot X^{1.356}$$

where Y = estimated body length in mm, and X = otolith radius.

The analysis of covariance showed that there was no difference between sexes in the body length-otolith radius relationship ($F'^{278}_{0.05} = 3.1$ and $F''^{278}_{0.05} = 1.041$).(*) A nomograph (Le Cren, 1947) was used to adjust the back calculated length for allometric growth and the results are summarized in Table 4. Mouneimne (1970) found a linear relationship between the body length-scales radius in the pipers of the Catalane Sea. Our estimated lengths of fish in each age group was lower than those obtained by Mouneimne. This is probably due to the fact that our samples, for the estimation of back-calculated lengths, were caught in a single month, while Mouneimne's data represent fish that were caught in a period of at least one year. At any rate a similar relationship was observed during the study of the growth of *Prionotus evolans* using scales (Marshall, 1946) and otoliths (McEachran and Davis, 1970).

TABLE IV. – Back-calculated fork lengths (mm) at the end of each year of life by age class for 210 pipers, collected from the Saronikos Gulf (Greece) in November 1976.

Age Class	n° of fish	Mean calculated fork length at the end of the year							average Fork obser. length (mm)
		I	II	III	IV	V	VI	VII	
I	131	139.91							150.0
II	47	123.78	198.28						225.8
III	13	123.34	195.08	249.12					263.92
IV	12	131.0	189.75	245.92	287.08				308.83
V	3	129.0	207.0	274.67	318.33	358.33			368.0
VI	2	110.5	184.5	256.0	311.0	349.5	375.0		391.0
VII	2	120.25	205.0	266.5	310.0	345.0	391.5	425.0	444.0
mean length (mm)		134.14	196.61	251.83	296.95	352.0	383.25	425.0	
annual increment (mm)		134.14	62.47	55.22	45.12	55.05	31.25	41.75	

The Rosa Lee's phenomenon is not very clear and it is observed only in the young age groups (I-III). The pipers grow rapidly during the first growing season. Young-of-the-year often attain 31.5% of their maximum adult size which exceed 134 mm in length. This growth is clearly shown by the rapid increase in the maximum size of young-of-the-year throughout the collection period. Then, a small delay in growth is observed up to the fourth year (Fig. 7). The increments ranged from 45.1 to 62.5 mm in the second through the fourth year and from 55.0 to 31.25 mm in the fifth through the seventh.

A difference between back calculated lengths and observed lengths for the older age groups was found. There are several possible causes for this : technical, selective mortality and biased sampling (Ricker, 1969). This is a well recognized phenomenon in fisheries population dynamics.

(*) F' is the F value for the homogeneity of regression coefficients, and F" is the F value for the adjusted means difference.

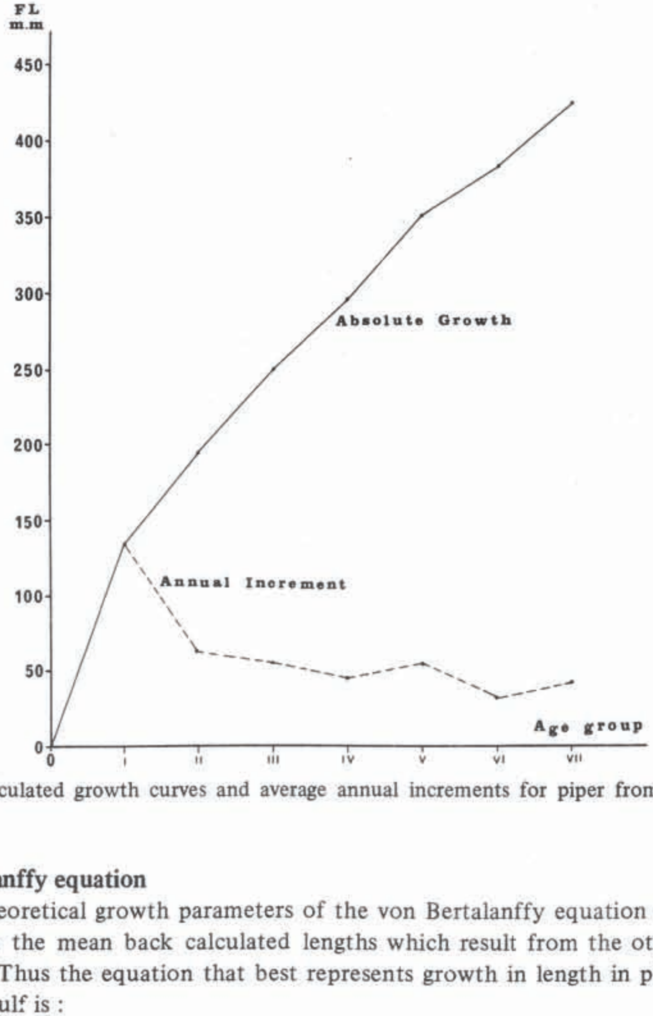

Fig. 7. – Calculated growth curves and average annual increments for piper from Saronikos Gulf.

Von Bertalanffy equation

The theoretical growth parameters of the von Bertalanffy equation were computed from the mean back calculated lengths which result from the otolith measurements. Thus the equation that best represents growth in length in pipers from Saronikos gulf is :

$$L_t = 740.49\,(1 - e^{-.11(t+.811)})$$

where L_t = fork length in mm in the age T, and T = the age in years.

The maximum estimated fork length (740.49 mm) does not seem to be unrealistic because many authors (Bougis, 1959 ; Bini, 1968 ; Soljan, 1975, and Tortonese, 1975) report that the piper's length is more than 60 cm in the Mediterranean Sea. Mouneimne (1970) has calculated the maximum total length of the piper to be 52 cm in the sea off Banyuls-sur-Mer.

Growth in weight.

Pipers that were used to calculate the relationship between length and weight were mostly immature. The equation, $W = a \cdot FL^b$ (where W is the weight in g, FL the fork length in mm and a, b constants), has been calculated by the method of least squares for each season of the year, separately for each sex. Comparing the weight-length relationship between the two sexes in each season of the year using covariance analysis, no difference was found ($P > 0.05$), so the sexes were combined. However, the difference of the above relationship was significant ($P < 0.05$) in the combined sexes between seasons :

spring : $W = 0.000020 \cdot FL^{2.833}$ $r = .993$ $n = 110$
summer : $W = 0.000017 \cdot FL^{2.878}$ $r = .998$ $n = 50$
autumn : $W = 0.000016 \cdot FL^{2.873}$ $r = .995$ $n = 100$
winter : $W = 0.000016 \cdot FL^{2.877}$ $r = .991$ $n = 284$

The high correlation coefficient (r) shows the homogeneity of the samples.

The somatic weight reaches its maximum in June and then decreases progressively from autumn to spring (Fig. 8). In the adults, these changes appear to be related to maturation and spawning, while in the young, to abiotic factors and food quantity. Each species of fish has its own optimum temperature in which metabolism and growth are more rapid (Nikolski, 1976).

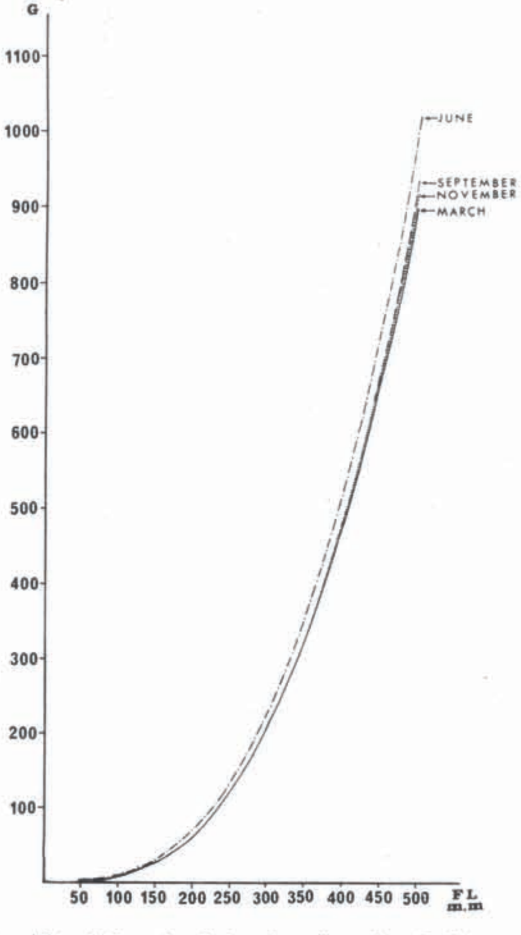

Fig. 8. – Length-weight relationship of piper from Saronikos Gulf in each season of the year.

The coefficient of condition was calculated separately (Table 5) for each one of the four seasons, according to Fulton (1904) and Clark (1928) assumptions. No significant difference was found between males and females (t-test, $P > 0.05$) so both sexes were combined. Clark's coefficient of condition does not depend on gonad weight or stomach content and is thus more sensitive to the influence of the environment and to seasonal changes in the fish condition. Therefore, it is a reasonable indicator of the adaptation of a species to different biotopes. The coefficient of condition did not present significant changes in our samples during the year. This occurred because most of the specimens were immature and all of them came from the same geographical area. A maximum was noticed in summer and a minimum in winter. The annual change of condition factor was found to be indirectly proportional to the annual change of the length-weight relationship.

TABLE V. – Coefficient of condition of pipers caught in Saronikos gulf from March to November 1977.

Season	Fulton	Clark
Spring	0,88	0,79
Summer	0,94	0,82
Autumn	0,91	0,80
Winter	0,85	0,77

Sex ratio.

The sex distribution was examined for 435 pipers which were collected in 1977. The males were more numerous during all the four seasons of the year and constituted 59,3% of the catches in Saronikos gulf. In the combined collections the number of males dominate in most age groups, but this percentage decreases with growth (Table 6). X^2 - test showed significant heterogeneity in the number of specimens both in each are group ($X^2 = 69.58$, $P < 0.05$) and in each season of the year ($X^2 = 46.44$, $P < 0.05$). These annual fluctuations may have been affected more by the seasons of collection than by the annual changes.

TABLE VI. – Numbers of male and female pipers in each age group caught in Saronikos Gulf during 1977.

	Age Group								
Sex	0	I	II	III	IV	V	VI	VII	%
male	89	124	30	10	4	-	--	1	59,3
female	48	85	26	4	8	3	2	1	40,7

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